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ABSTRACT

Animation, still graphics, and text only were compared for their effects on the acquisition of the mathematics skill of using a compass to create triangles. Attitude toward instruction was also studied. It was hypothesized that animation would result in greater achievement of the learning task, and that text alone would yield the lowest achievement. The same hypotheses were posed for attitude toward mathematics instruction by computer. The computer-based instruction used a single lesson from a tenth-grade mathematics curriculum. Subjects were 147 undergraduate elementary education majors in a mathematics teaching methods course. Subjects who studied the animated lesson scored significantly higher than those using the still graphics. They, in turn, scored above those using only text. Attitude scores were equivalent for animation and still graphics groups, but were lower for the text only group. Recommendations are made for the use of graphics and animation in mathematics instruction. Two tables and one figure illustrate the discussion. (Contains 14 references.) (SLD)

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Effects of Animation & Visuals on Learning High School Mathematics

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MULTIMEDIA

Educators have used the term multimedia in a global sense for years: outside the classroom the term was rarely heard. Research on components of multimedia was spurred after the second World War by the military interested in increasing training effectiveness and conducted by new research graduates eager to carry out the studies. For example, a research team was formed at Penn State which for years investigated the effects of movies on learning outcomes. Later the thrust moved to video and through the work of Dwyer and others has concentrated on the roles of graphics and color in learning.

In recent years, the prospects of huge businesses to be spun out of the multimedia and information superhighway efforts has brought the term multimedia out of the closet and into the public view. For example, Naisbitt (1994) in his newest look to the future has written that multimedia will become a dominant force in the next decade and the two most significant applications will consist of entertainment and education. On the communications-side of things, software giant Microsoft and cellular phone giant McCaw recently announced plans to blanket the earth with communcations satellite to make electronic communication available anywhere in the world. The potential for such systems to impact education and training is enormous, but what does the research tells us about the field.

For now multimedia may be defined as the components of conventional media (computer, video, graphics, animation, audio, color) along with their path to complete integration, which is now just in its infancy.

On the assumption that understanding and directing the formation of the whole can be increased by examining its parts, this paper will examines the multimedia component of animation. Animation is examined as it is the new kid on the block and which will likely grow quickly as the hardware and software systems which brought us desktop publishing and desktop video will soon bring desktop animation to educators and trainers.

GRAPHICS AND ANIMATION IN INSTRUCTION

Research Findings

Graphics in instruction is defined as any representation of an object, concept or process, as perceived through the eye, which does not rely on the use of text or numbers. Animation refers to the use of a series of graphics which change over time.

Extensive research on graphics occured during the 1960's and 70's and has diminished in recent years. Subsequent to these studies which support the positive effects of graphics on achievement, the computer has become the dominant mode of instruction in education. Apparently researchers believe the findings and conclusions will continue to be valid with graphics delivered by computer based instruction (CBI). This argument makes the plausible

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assumption that the type of feature represented in instruction is more important than the number of different ways it is represented.

It was found that graphics and visuals increase the amount learned by adults (Alesandrini, 1984) and by children (Pressley, 1977). Alesandrini and Rigney (1981) found graphics to be an effective review strategy compared with verbal strategies. In a study which examined student attitude toward graphics-based learning, Rigney and Lutz (1976) concluded that using graphics as analogies in CBI resulted in high levels of satisfaction with the learning experience.

Willows (1978) was concerned about potential interference between the messages provided by text and graphics in textbooks. Unlike texts, CBI, permits control over the presentation to avoid such conflicts. For example, turning a page of a book may reveal a graphic and text, but with computer control, the graphic can be presented first and the text held until a certain time had expired, or vice versa.

Dwyer (1970) showed that simple line drawing graphics tend to be superior to photographs or other more realistic drawings. The key seems to be the relevance of the cues to the learning task. For example, using a photograph of a car engine to teach about the location of the carbeurator might be appropriate in terms of relevant cues, whereas the same photograph would be inappropriate to teach about the structure and function of the carb itself.

Joseph and Dwyer (1982) concluded that the integration of realistic and abstract graphics may reduce achievement differences between students of different ability levels. This appears to interact with the concreteness or abstractness of the topic to be learned. In teaching about computers, for example, the parts of a computer can be highly concrete and easy to represent graphically, while the functions of a computer are quite abstract and therefore not as conveniently represented.

Rigney and Lutz (1976) elaborated effects of graphics in instruction by urging students to form mental images as they studied the material. Increased learning resulted from this combination. These results are supported by the research of Canelos (1979) who showed that training in visual imagery techniques resulted in better learning on a highly visual but real-world memory task.

Another factor about graphics needs to be considered for both research and learner evaluation. The amount learned from instruction using graphics can be suppressed and appear not to have been learned if the examination does not contain the graphics stimuli that were present during learning. Szabo, DeMelo & Dwyer (1981) showed that achievement scores were significantly higher when the graphics used during instruction were incorporated into the testing protocol.

Animation does not have the rich research history that is associated with color and graphics. This may be due to the fact that until recently, creation of animation required mainframe computers with complex software and high skill levels. Today, basic animations can be created using micros and relatively inexpensive and easy to use software. Furthermore, today's computers are capable of high resolutions of 72 pixels per square inch, 24 bit color (14M colors), and 30 frames per second video. While the realism provided by the new technology seductively implies increased learning effectiveness, prior research results showing the superiority of simple graphics should make us cautious about assuming effectiveness.

In an early study using movies to provide animation, motion was shown to be superior to slides or sequential photos in presenting time- and motion-based concepts (Wells, 1973). The reverse was true for concepts involving the presentation of spatial entities.

Baek and Layne (1988) compared learning conditions of text only, text plus graphics, and text plus animation. The adults in the study scored higher in the animation condition than either text or graphics. The animation condition also resulted in less study time, suggesting that animation results in more efficient learning. In another study with adult learners, Mayton (1991) found increased scores in the animation condition immediately after study persisted and were measurable one week later.

Rieber and Boyce (1990) compared animation-based instruction with carefully designed verbal presentations which used highly imaginative examples and illustrations. The results with an adult sample indicated no significant difference in the amount learned but the animation group

required less time to retrieve the information they learned. One would have to ask whether the results would follow with children who may not have sufficient experience bases to accurately imagine the examples and illustrations used.

It remains to be seen whether the gains in learning or reductions in learning time that animation seems to offer are worth the added time and energy needed to create animations, compared with other forms of instruction such as mental imagery and visual elaboration.

A RECENT STUDY COMPARING ANIMATION, GRAPHICS AND TEXT

Goal of the Study

The authors recently completed a comparison of animation, still graphics, and text only on the acquisition of the mathematics skill of using a compass to create triangles and attitude toward the instruction (Poohkay, 1994). It was hypothesized that animation would result in greater achievement of the learning task, followed by graphics, and lastly text would yield the lowest achievement. The same hypotheses were posed for attitude toward mathematics instruction by computer. The instruction was delivered by computer based instruction.

Materials and Methods

The instruction used a single lesson from a larger, grade 10 mathematics curriculum designed for distance delivery. The objective of the lesson was to be able to use a compass to create triangles from given line segments. Three versions of the lesson were developed and differed only in their use of graphics. The animation lesson included several animations of the process of constructing triangles with a compass. The graphics version replaced the animations with a series of static graphics. The text-only version used no graphics at all. See Figures 1 and 2 below for the graphics and text versions, respectively. (The animation sequence will be demonstrated as part of the formal presentation of this paper)

Lessons were developed using Authorware Professional for the Macintosh and delivered on a network of Macintosh IIci s. The sample of 147 volunteers was drawn from a group of undergraduate elementary education majors who were completing a required course in elementary mathematics teaching methods.

One hundred percent of those approached agreed to participate in the study which was conducted during one scheduled class period. Upon entering the computer lab, students completed an informed consent form and a mathematics skill pretest. They were then randomly assigned to the instruction using one of the three instructional methods noted above. As they completed the lesson, they were tested on their ability to draw several triangles using compasses provided by the researchers. Finally, they completed a Likert-type scale which assessed attitude toward mathematics instruction by computer.

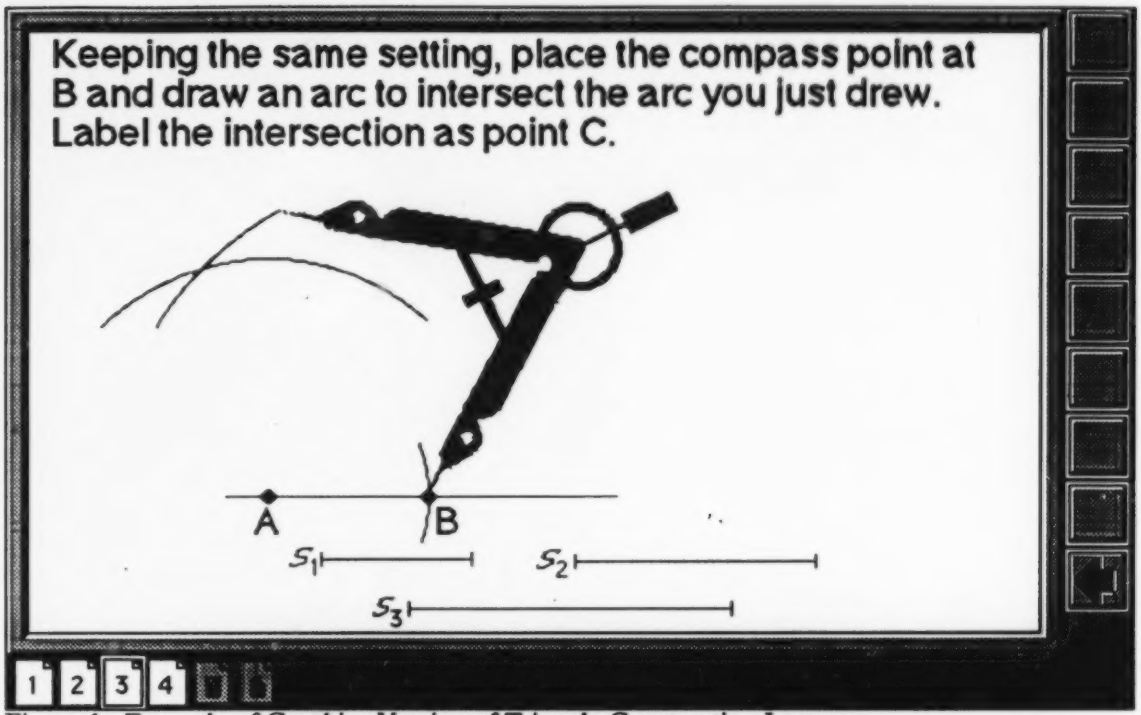
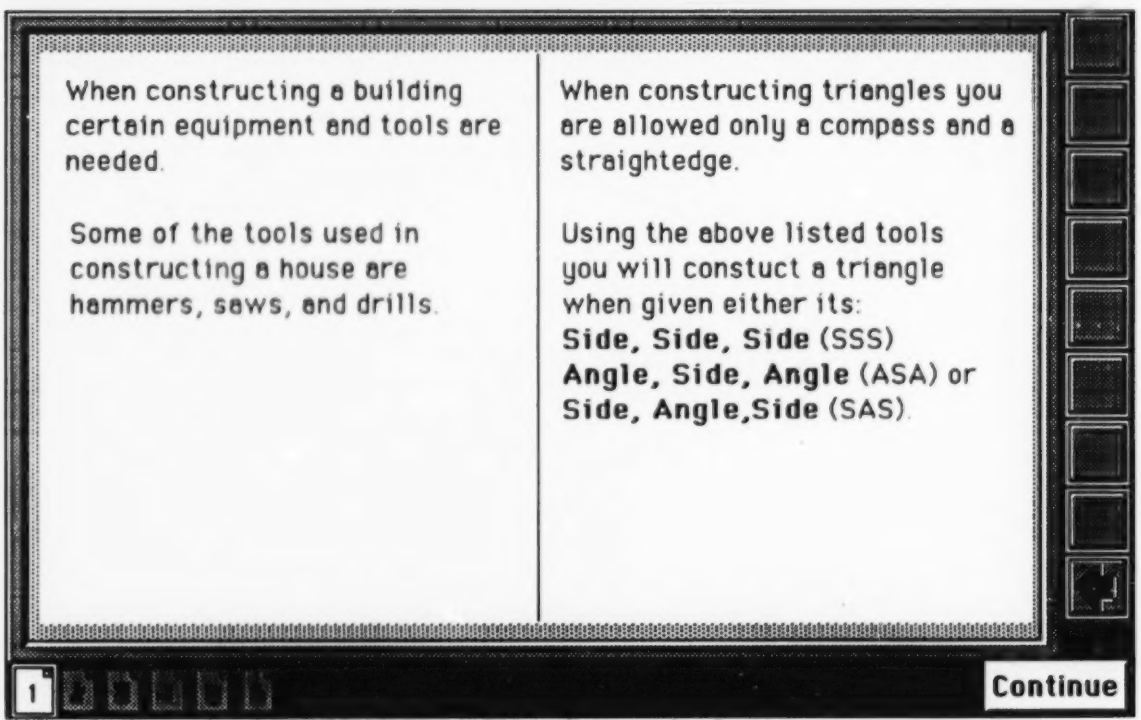


Figure 1. Example of Graphics Version of Triangle Construction Lesson


When constructing a building certain equipment and tools are needed.
Some of the tools used in constructing a house are hammers, saws, and drills.
When constructing triangles you are allowed only a compass and a straightedge.
Using the above listed tools you will constuct a triangle when given either its:
Side, Side, Side (SSS)
Angle, Side, Angle (ASA) or
Side, Angle,Side (SAS).
1
Continue
Figure 2. Example of Text Version of Triangle Construction Lesson

Achievement and Attitude Findings

As predicted, students who studied the animated lesson scored significantly higher than those using the graphics lesson who in turn scored significantly higher than those using the text only version. Table 1 presents the ANOVA summary table and means scores.

Table 1. ANOVA Summary Table and Mean Achievement Scores of Treatment Groups

Source	d.f.	Sum of Squares	Mean Squares	F- Ratio	Probability
Between Groups	2	3890.73	1945.36	32.34	< 0.00
Within Groups	170	10226.66	60.16		
Total	172	14117.39			

Treatment	Mean	Standard Deviation	Cases
Text	6.9	5.8	59
Graphics	11.4	8.1	57
Animation	18.4	9.1	57
Total	12.15	9.1	173

When the criterion was attitude toward mathematics instruction by CBI, the animation group had significantly higher attitude scores than the text group and equivalent scores to the graphics group (Table 2). Attitude was defined by a Likert-type scale designed to measure attitude toward the learning of mathematics by CBI.

Table 2. ANOVA Summary Table and Mean Attitude Scores of Treatment Groups

Source	d.f.	Sum of Squares	Mean Squares	F- Ratio	Probability
Between Groups	1	550.12	550.12	6.93	< 0.01
Within Groups	171	13567.27	79.34		
Total	172	14117.39			

Treatment	Mean	Standard Deviation	Cases
Text	72.5	13.1	59
Graphics	79.4	11.5	57
Animation	79.8	11.0	57
Total	77.2	12.3	173

Recommendations for the Use of Graphics and Animation

Several recommendations serve as useful guidelines for the use of graphics and animation in CBI. These recommendations stem from the research literature and study cited above, supplemented by the personal experience of the authors.

1. Analyze the relevance of graphics/animation cues to the learning outcome and use those cues appropriately in the instructional, practice, and testing situations relative to the particular learning objectives.

2. Opt for graphics in animations which are simpler in design to optimize learning.

3. Examine graphics/animations for these criteria
   a. sense of perspective, e.g., relative size, speed, and path of motion

b. ability to convey the time- or motion-based aspects of animation in a single viewing, alternatively provide the learner with multiple opportunities to replay the animation.
c. clarity of representation, which may be effectively enhanced by the use of text labels
d. the desirability of showing the animation from multiple perspectives.
e. the ability of the learner to interact with and modify the graphic/animation.

4. Seek the advice/development expertise of a graphics/animation specialist.

5. Test out prototype lessons using different graphics/anmations with your target population of learners.

6. Test prototype lessons on the complete range of target delivery machines. Various machines are capable of different speeds of running the animation or drawing the graphic and give rise to different effects which can be quite different from that intended.

7. Complex animations may not be optimal for beginning learners (Rieber, 1990).

8. The real contribution of animation may be in the realm of interactive graphics (Siliasukas, 1986). However, few have been constructed for general education due to the enormous complexity and expense involved.

9. Enhance the encoding power of graphics or animations by engaging the learners in the creation and use of mental imagery during instruction.

10. Enhance the decoding power of graphics or animations by using the same graphics and animations in testing situations as were used in the instruction.

CONCLUSIONS

The substantial amount of research conducted to determine effects of graphics on learning suggests a high level of effectiveness for graphics. Beyond thes generalization there are specific situations in which use of graphics must be carefully planned. Comparatively much less research has been conducted with regard to animation as an instructional tool. Based on results to date, one might conclude that animation has a positive and significant effect upon learning outcomes.

Whatever media are used, it is recommended that one carefully analyze the relevant, irrelevant, and counterproductive cues of any learning task and create or select media which strike a proper balance relative to those cues.

Consider the nature of the target population of learners relative to the media chosen in terms of ability, experience, or maturity level.

Recognize that media has the potential to add significant visual appeal to instruction but that visual appeal is not known to be correlated to instructional effectiveness. At the same time significant visual appeals sells products.

Consider enhancing learning by combining media with non-media instructional methods to optimize learning. For example, the use of icons to convey complex symbols is often subject to misinterpretation, which can be easily eliminated by addition of simple text. The use of graphics and animation may be enhanced by incorporating procedures and training in the use of visualization techniques.

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